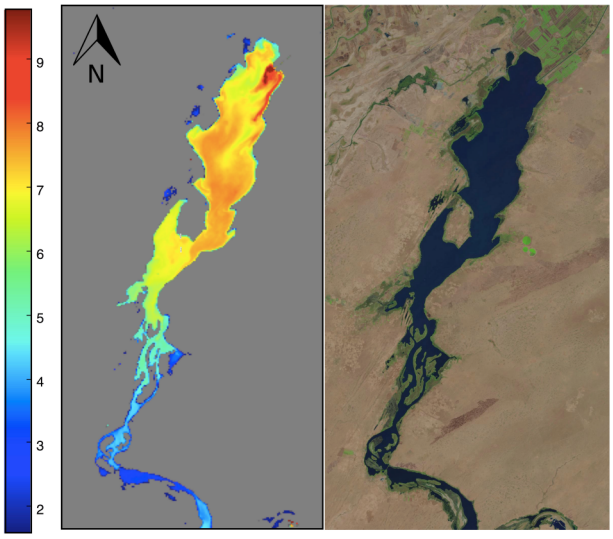


Landsat-derived concentration of Total Suspended Solids, TSS, (left) of Lake Guiers in Senegal. The warmer colors indicate more turbid waters. The highest TSS concentrations are associated with areas where water flows into the lake from the Senegal River. The true-color image (acquired Jan 21, 2014) is shown to the right.

TECHNICAL BRIEF

Reporting on SDG Indicator 6.6.1 Using Satellite Earth Observations

Indicator 6.6.1 tracks changes over time in the extent of water-related ecosystems. While analysis of ground-based, survey data and in-situ measurements is as an important part of SDG monitoring and reporting, there is potential for countries to utilize satellite-based Earth observations to meet some of the reporting requirements of Indicator 6.6.1, pertaining to both spatial water extent and quality of waterbodies and wetlands. In collaboration with the Group on Earth Observations (GEO) and space agencies such as NASA, ESA, and JRC, UN Environment has identified a series of activities that focus on the use of Earth observations to support the monitoring and data collection process for this indicator.

The UN Environment-NASA collaboration

Global monitoring of Sustainable Development Goal (SDG) 6 – ensure availability and sustainable management of water and sanitation for all – was initiated in early 2017 following development, testing, and evaluation of methodologies for monitoring the associated indicators. Target 6.6 of SDG 6 calls for the protection and restoration of water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. The first indicator of this target, Indicator 6.6.1, tracks changes over time in the extent of water-related ecosystems. UN Environment is the custodian agency for this indicator and has developed a step-by-step methodology that explains how to monitor change in the extent of water-related ecosystems over time. A pilot initiative by UN Environment and NASA has been developed to explore the applicability of Earth observations datasets and tools that can be used with country-level generated data to support national reporting on this indicator.

The UN Environment-NASA pilot effort does not intend to replace the country-owned process of SDG data collection and submission; rather, this initiative intends to explore the applicability of Earth observation data to complement country-generated data. The goal of the initiative is to extract information relevant to meeting the reporting requirements of SDG Indicator 6.6.1 from Earth observations data for a select group of pilot countries, utilizing openly available, free of charge datasets and tools. In its custodian agency role, UN Environment will subsequently aim to efficiently distribute the successful methods and datasets to countries to support their data-driven decision-making regarding this indicator.

Proof of concept for select pilot countries

A NASA-University of Maryland research team carried out a proof of concept for the initiative, focusing on the ecosystem categories of vegetated wetlands (coastal mangroves only) and open water (rivers and estuaries, lakes and reservoirs). Two of the three principle water ecosystem sub-indicators, as defined by the UN Water publication "Integrated Monitoring Guide for SDG 6", were mapped and measured: the spatial extent of water-related ecosystems, and the quality of water within these ecosystems. The following aspects of the indicator were analyzed by the team:

1. Spatial extent for open waterbodies,
2. TSS and Chlorophyll for inland waterbodies,
3. Spatial extent for coastal mangroves.

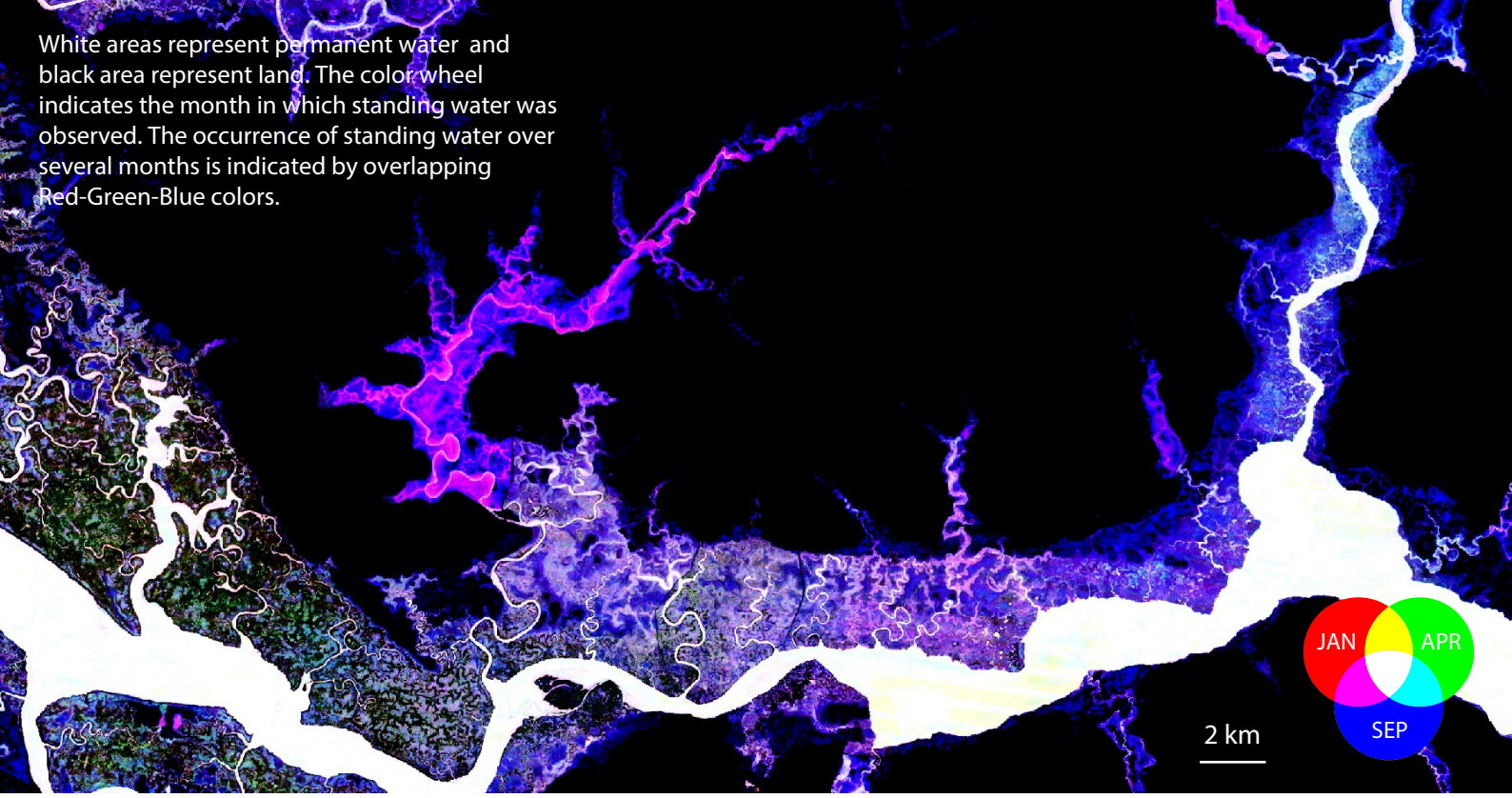
For the extent of open waterbodies the pilot countries included Cambodia, Jamaica, Peru, Philippines, Senegal, Uganda and Zambia. A proof of concept for the extraction of the water quality indicators of Total Suspended Solids (TSS) and Chlorophyll was also provided for select large open waterbodies in the countries of Peru, Senegal and Zambia. Pilot countries for the spatial extent of coastal mangroves included Jamaica, Peru and Senegal. All of the satellite-based Earth observations datasets that were used are of global coverage and publically available at no cost, making them a particularly attractive option for data-scarce regions. The temporal consistency and long timeseries of these datasets and methods also enables replicability over time, making reporting of change from baseline values over time consistent and systematic.

Information on the methodologies used can be found at: http://eo4sdg.org/earthobservations-for-sdg6monitoring/

Summary of the components measured and datasets used for the pilot study

Water Ecosystem Measured	Sub-indicators Measured	Datasets	Spatial Resolution (m)
Open water	Spatial extent	MOD44W C6.1*	250
Open water	Spatial extent	Landsat-5, 7, and 8*†	30
Lakes & reservoir	TSS and Chlorophyll	Landsat-8*† and Sentinel-2A‡	20-30
Wetlands (coastal mangroves)	Spatial extent	Landsat 8 OLI*†, Sentinel-1C‡, SRTM*	30

*National Aeronautics and Space Administration (NASA) †US Geological Survey (USGS) ‡European Space Agency (ESA)



Mean surface water extent for January, April, and September of 2013-2015 mapped with Landsats 7 and 8
Casamance River, Senegal

Mapping water extent: MODIS vs. Landsat

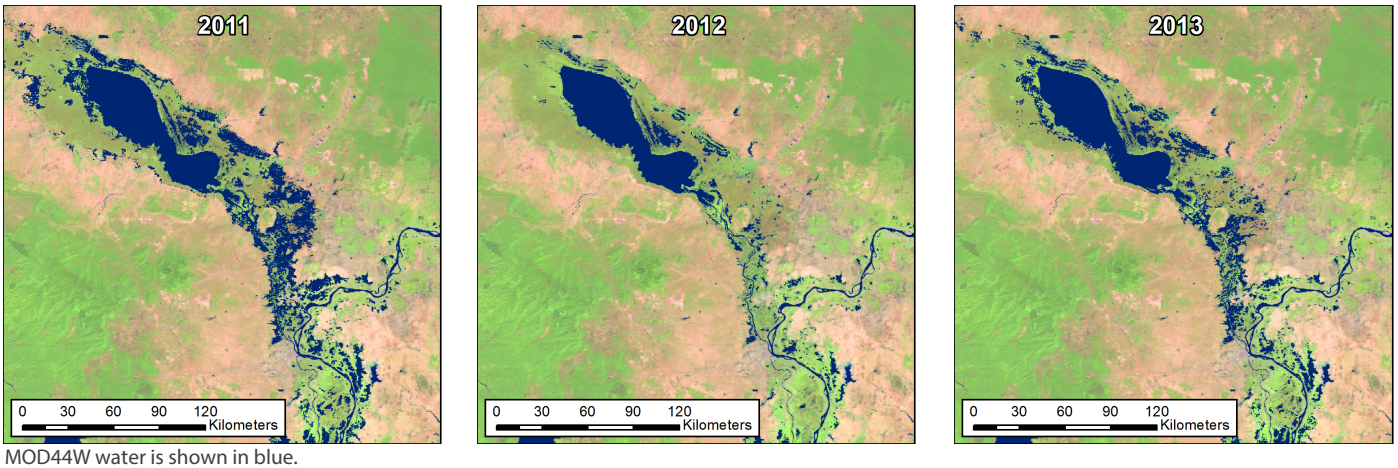
Two different Earth observations datasets were used to map and measure surface water extent of open waterbodies in seven pilot countries: the Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat. The two datasets differ in spatial and temporal resolution and ultimately in the methodology used for extracting data for reporting on SDG 6.6.1. Landsat can resolve much smaller landscape features than MODIS, given it's higher spatial resolution of 30 m versus 250 m with MODIS, thus Landsat-based water products are able to map smaller waterbodies and capture a greater amount of landscape detail (above). However, annual maps created from the daily coverage MODIS data have a higher likelihood of accurately measuring surface water extent in areas with limited imagery due to cloud cover than those created from sensors with lower temporal resolution, such as the Landsat constellation, which between Landsats 7 and 8 images the globe every 8 days. This also enables capturing interannual variability more easily (below). Generally, Landsat is the most appropriate choice for smaller waterbodies, including rivers, while MODIS is more appropriate for medium to large waterbodies that are either in cloudy areas or that change rapidly. Medium to large waterbodies that meet these criteria can be accurately mapped with either sensor.

Water quality and coastal mangroves

Water quality measurements from Earth observations data present an exciting new opportunity for SDG reporting, and in general for many end-user communities interested in assessing the health and condition of waterbodies over time. The Landsat-Sentinel-2 satellite data, if processed via appropriate tools, enables capturing dynamics of optically-detectable SDG water quality indicators, including concentrations of Chlorophyll-a (Chl) and Total Suspended Solids (TSS), two of the water quality sub-indicators required for reporting. The NASA team is planning to develop a satellite-based water quality warning system to be evaluated and tested for several bodies of water in various countries, including those in this pilot study.

The coastal mangrove extent data produced by this initiative can be used to generate country and district-wide extent estimates, which can be applicable for many countries. Trends of excessive gain or excessive loss - found to be significant for some of the pilot countries studied - can be critical in determining key locations for future sustainable development projects, in addition to helping countries meet their SDG reporting requirements for Indicator 6.6.1.

Surface water extent mapped with MODIS-based MOD44W C6.0 data
Tonle Sap Lake, Cambodia



MOD44W water is shown in blue.